Lecture 17. Drift, Ne, Gene Flow

EEB 2245, C. Simon, 28 March 2017

Last Time..

- Usefulness of Hardy Weinberg
- Early 20th century perception of variation in natural populations
- Importance of Lewontin & Hubby 1966
- Importance of genetic variation
- Inbreeding
- Conservation Value
- Intro to Genetic Drift

This Time..

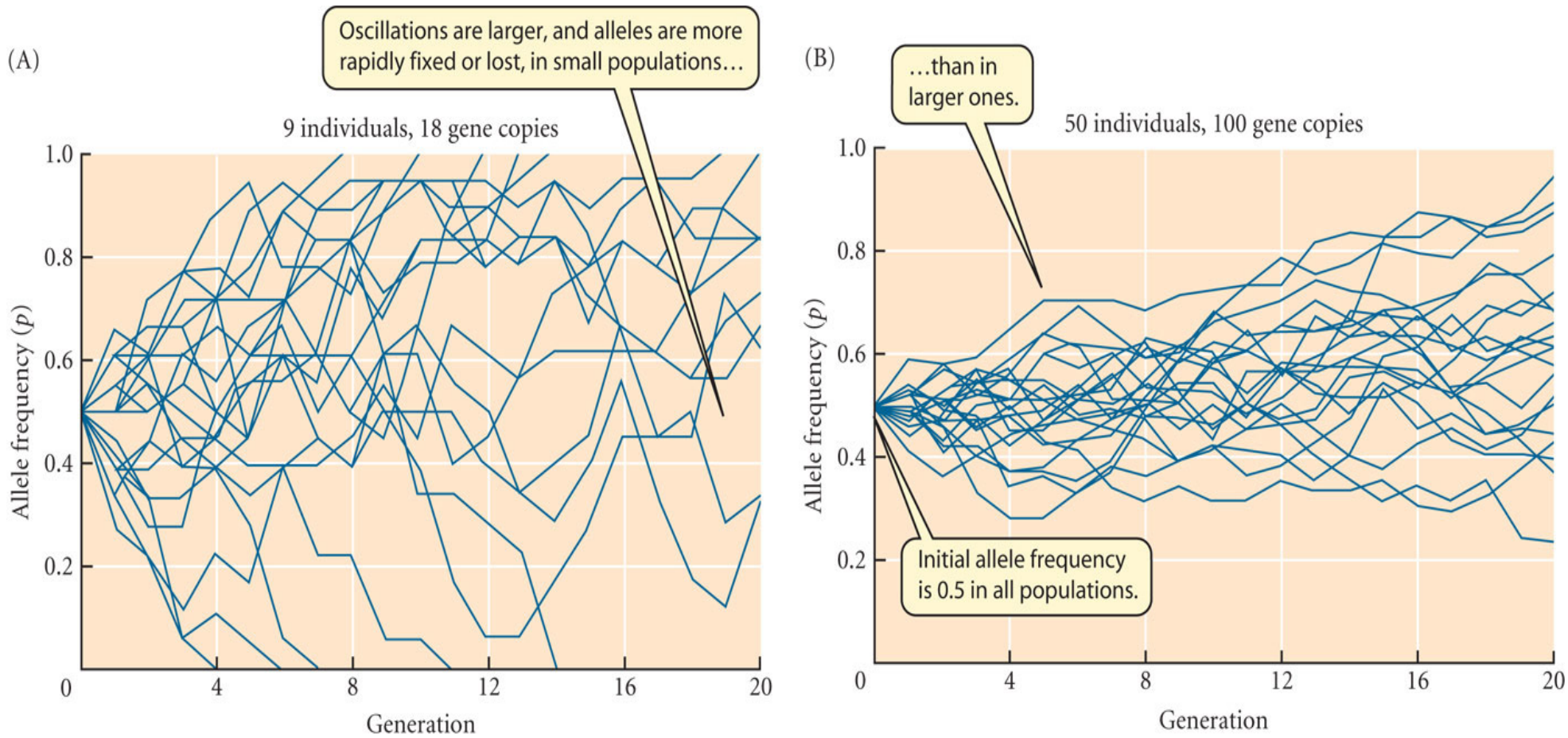
- Genetic Drift
- Effective population size
- Bottlenecks, Founder Effect
- Gene flow

Assumptions of Hardy Weinberg

- Diploid population
- No New Mutations
- Random Mating (no inbreeding)
- “infinite” population size (no drift)
- **No Migration of alleles**
- No Natural selection (or tight linkage w another gene under selection)
- Only one population has been sampled.

Small population

Large population



Futuyma, 3rd Edition, Fig. 10.3

Random genetic drift can result in non-adaptive evolution because one allele is replaced by another (fixed) by chance.

Genetic Drift

The effect of recessive allele freq. on heterozygosity:

allele freq.:

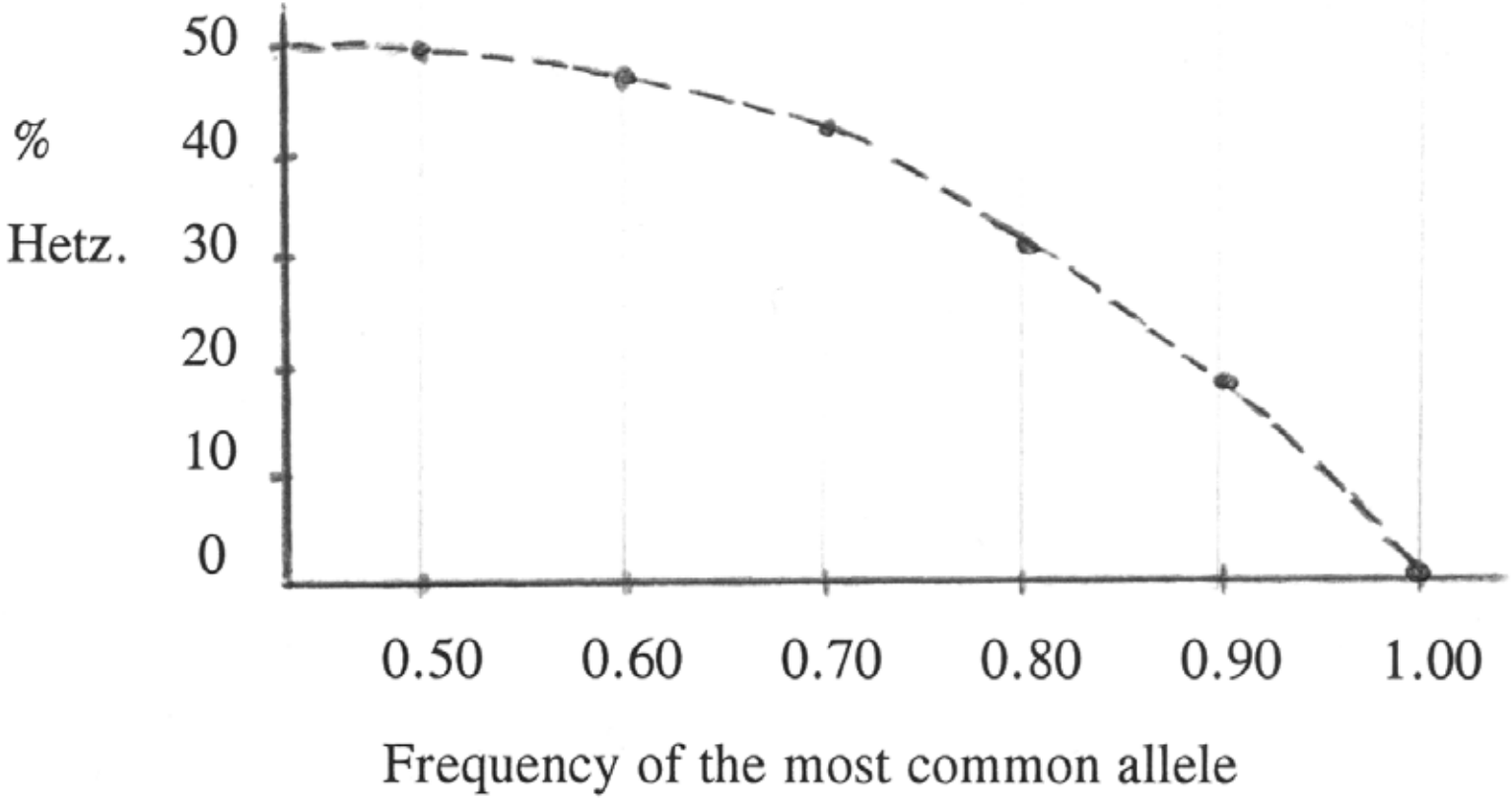
a =	0.5	0.6	0.7	0.8	0.9	“a” fixed
b =	0.5	0.4	0.3	0.2	0.1	“b” lost

Genotype freq. (at H-W equilibrium):

aa =	0.25	0.36	0.49	0.64	0.81
ab =	0.50	0.48	0.42	0.32	0.18
bb =	0.25	0.16	0.09	0.04	0.01

Genetic Drift

Note that as one allele becomes rare, the proportion of heterozygotes (the heterozygosity of the population) declines as a direct consequence



Effective Population Size, Ne

Reasons for N_e not equal to census size

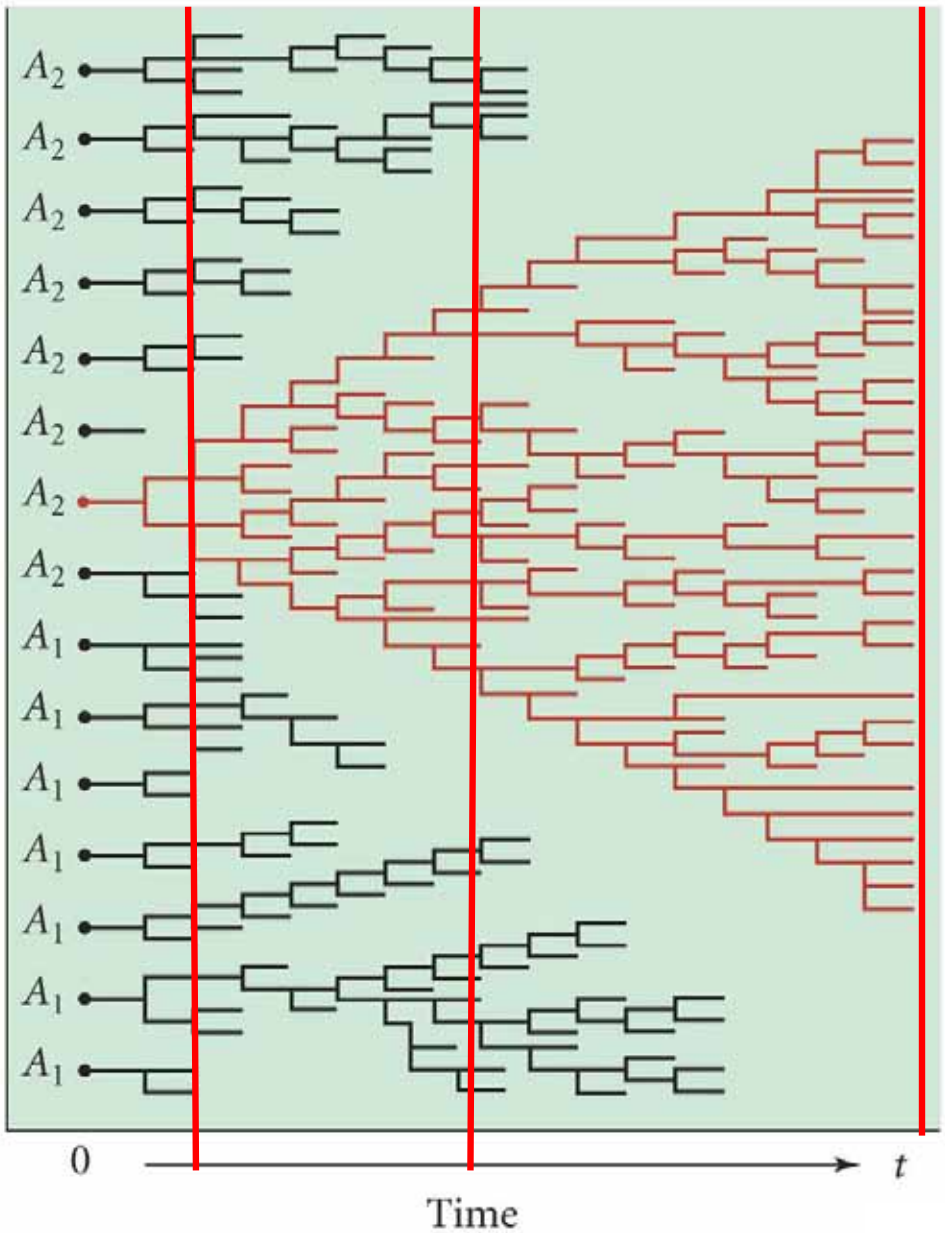
1) Some males or females don't mate.
   a) Dominant males, harems (or sex ratio not 1:1)
   b) Sneaky males may achieve secret matings
   c) Observed matings may be thwarted.

Consequence: Some individuals leave fewer progeny than others (increases inbreeding)

Elephant seal territoriality https://www.youtube.com/watch?v=JrzenOfcmBo

Video clips: Hedge sparrow from BBC, David Attenborough's "Life of Birds" series, "Finding Partners" http://www.bbc.co.uk/programmes/p007tx02

Coalescence & inbreeding



Initially 15 copies. Most go extinct by chance. **Average relatedness increases over time**

At time "t" all copies "descend from" or "coalesce to" a single ancestor

Smaller poplns, faster coalescence

Time to coalescence is 2N generations, where N= popln size

Futuyma, 3rd Edition, Fig. 10.1

Additional Reasons for N_e not equal to census size–

2) Sex ratio different from 1 : 1 (similar effect to harems)

3) Natural selection causing progeny number to vary among genotypes

4) Given overlapping generations, offspring may mate with parental generation

5) Fluctuations in population size over time

Drift generally depletes genetic variation

However, in certain circumstances drift can actually enhance genetic variation.

Applications of genetic drift to conservation Biology

Conservation Problem:

You are a population biologist and you are called upon to help save an endangered species that if left alone will soon be eliminated in the wild by an introduced predator. The only hope is captive breeding.

Hypothetical organism

Facts: Populations are small; genetically isolated--widely scattered. You can only afford to maintain and breed 100 individuals.

Goal: Maintain as much genetic variability as possible; Keep costs manageable

Question: Is it best to collect 100 individuals from one population or 10 individuals from each of ten populations?

http://www.futuretimeline.net/blog/2014/06/1-2.htm#.V9lQuYWuQiE

Genetic bottlenecks- small population size

- Causes:
- natural environmental fluctuations (gradual or catastrophic)
- Human intervention- hunting or habitat conversion
- Founder events

http://animals.nationalgeographic.com/animals/mammals/cheetah/

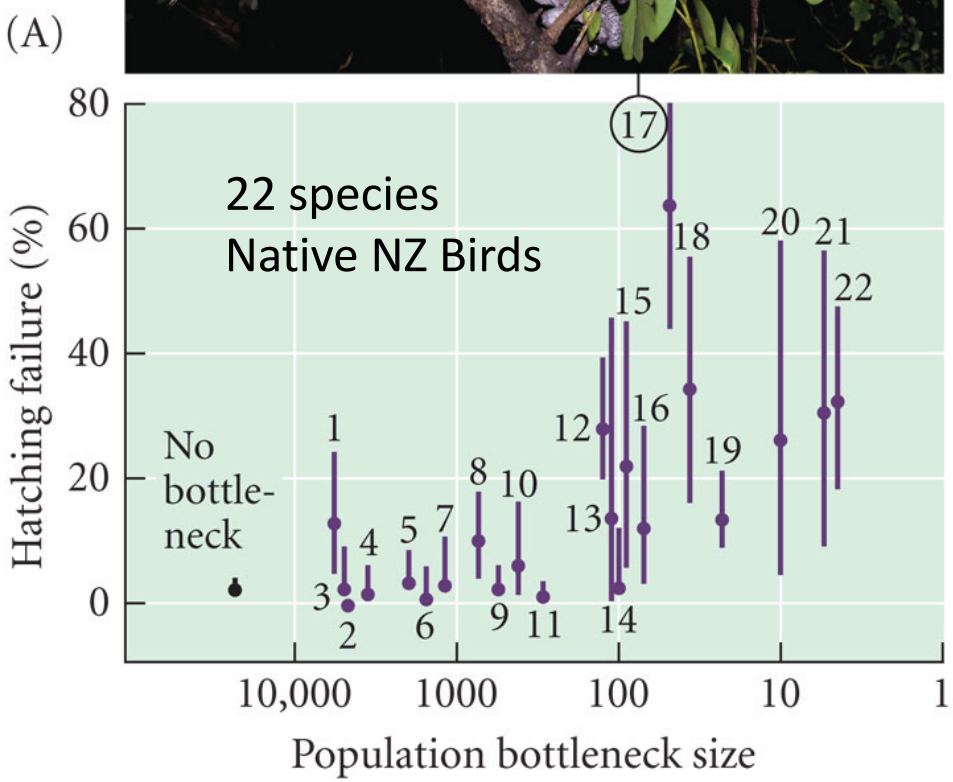
Northern Elephant Seal

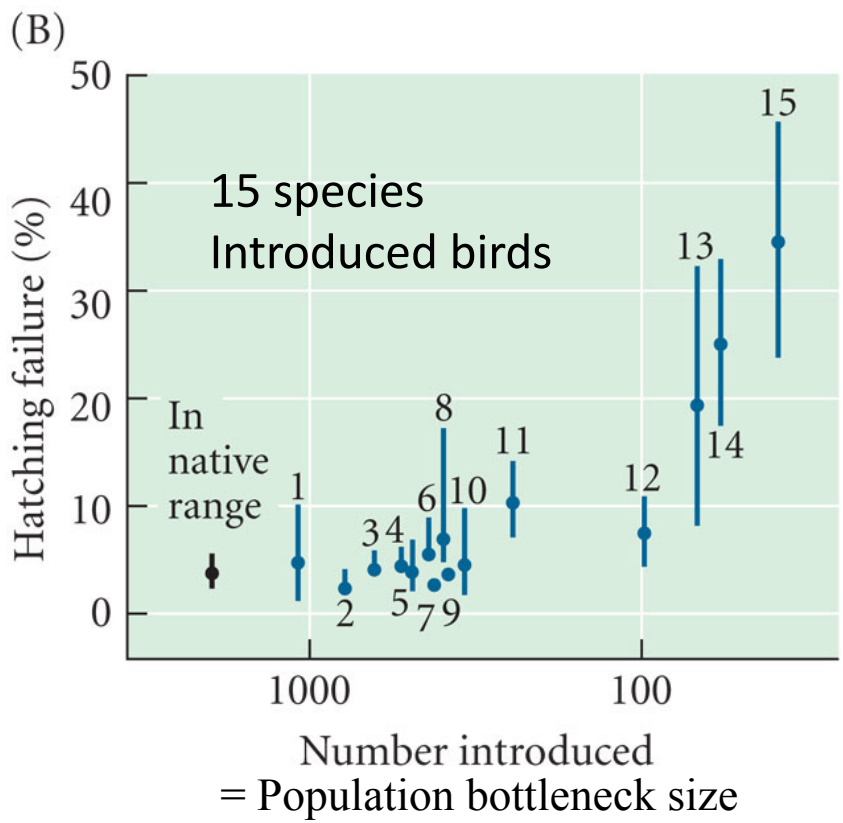
- Reduced by hunting
- 20 animals in 1890's.
- Harems- Avg. only 20% of males mate
- 1970's recovered to 30,000
- 1974 Survey: 24 allozymes
- All loci monomorphic (one allele)

Failure rate of egg hatching in NZ birds correlated with size of bottleneck

Strigops habroptila

2.3 minute video clip of Kakapo narrated by Benedict Cumberbatch
https://www.youtube.com/watch?v=E3a88_SjJR0





Futuyma, 3rd Edition, Fig. 10.9

Finnish People

Genetic Drift in Small Populations
(original colonists)

Bottleneck- separated for centuries
(4,000 yr)

Different set of genetic diseases

Pääbo et al. 1996. PNAS

DNA- Y-chromosome & mtDNA

54 Finns

28 Saami (resident Laplanders)

100 Europeans

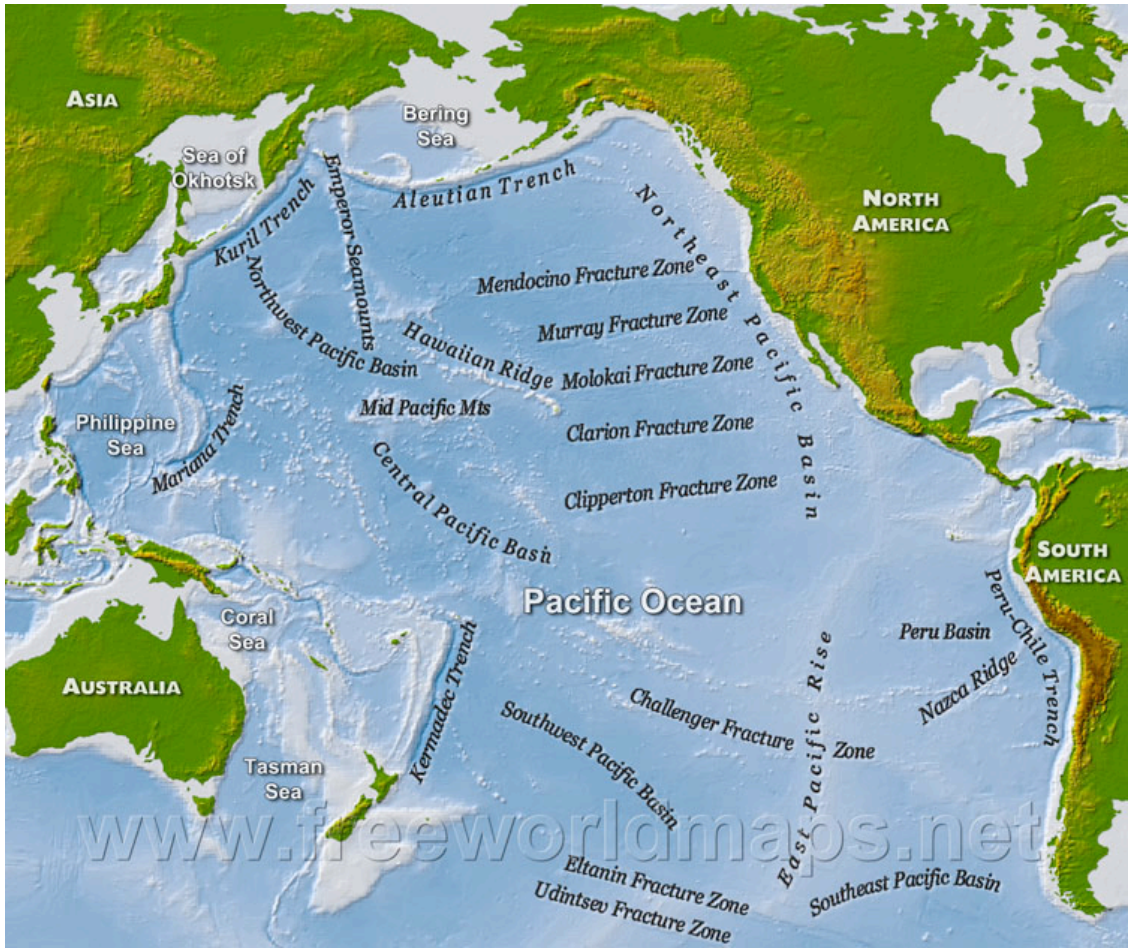
Finns least variable

http://i140.photobucket.com/albums/r4/swamimuktananda/finnland.jpg

Saami People

http://virtual.finland.fi/finfo/images/people/saami2.jpg; http://www.saminuorat.se/media/38957.jpg; http://www.arcticpeoples.org/wp-content/uploads/2008/02/ome-photo.jpghttp://upload.wikimedia.org/wikipedia/commons/thumb/8/87/Saami_Family_1900.jpg/800px-Saami_Family_1900.jpg

Founder events: one or a few individuals colonize an isolated area



Are oceanic islands deserts of genetic diversity?

Founder events and bottlenecks

- Two parents (or a pregnant female) founding a new population carry <u>at most</u> four different alleles at a given locus.
- At most loci, one, two or three alleles tend to predominate; <u>founders will most likely carry the most common allele</u>.
- Thus, many alleles will be lost in a bottleneck <u>no matter how long it is</u>
- Extended bottlenecks will tend to reduce variability further due to <u>genetic drift</u> in the small population
- Short bottlenecks will not reduce variability substantially as demonstrated next…

Effects of founder population size on population heterozygosity:

Given

H_0 = Source population proportion of heterozygotes

N = # of colonists

H_f = Heterozygosity of the founder

Population genetics calculate $H_f = (1 - 1/(2N))\ H_0$

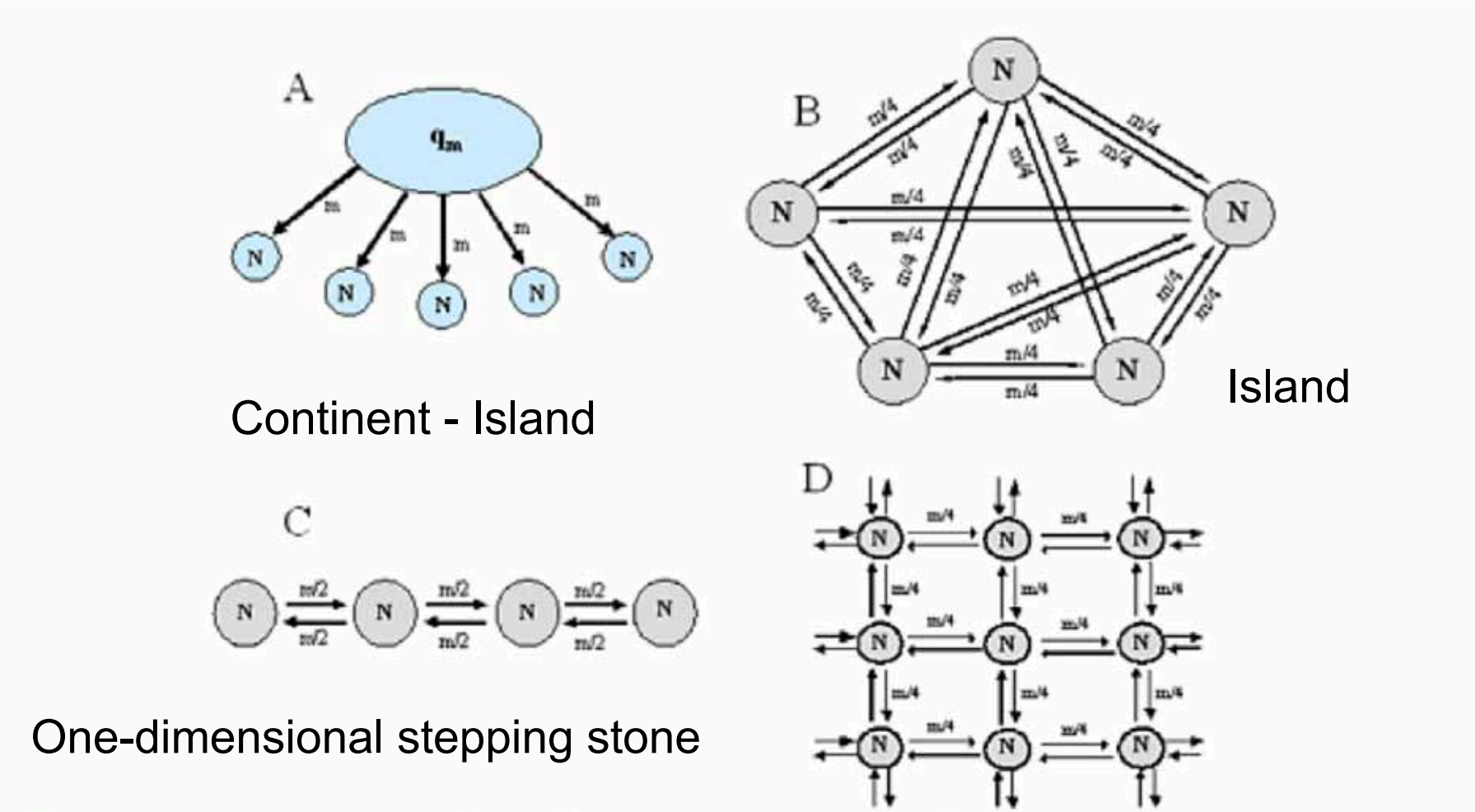
With N = two colonists

$H_f = (1 - 1/(2N))\ H_0$ or

$H_f = (1 - ¼\ )\ H_0$ or

$H_f = ¾\ H_0$

Models of Gene Flow



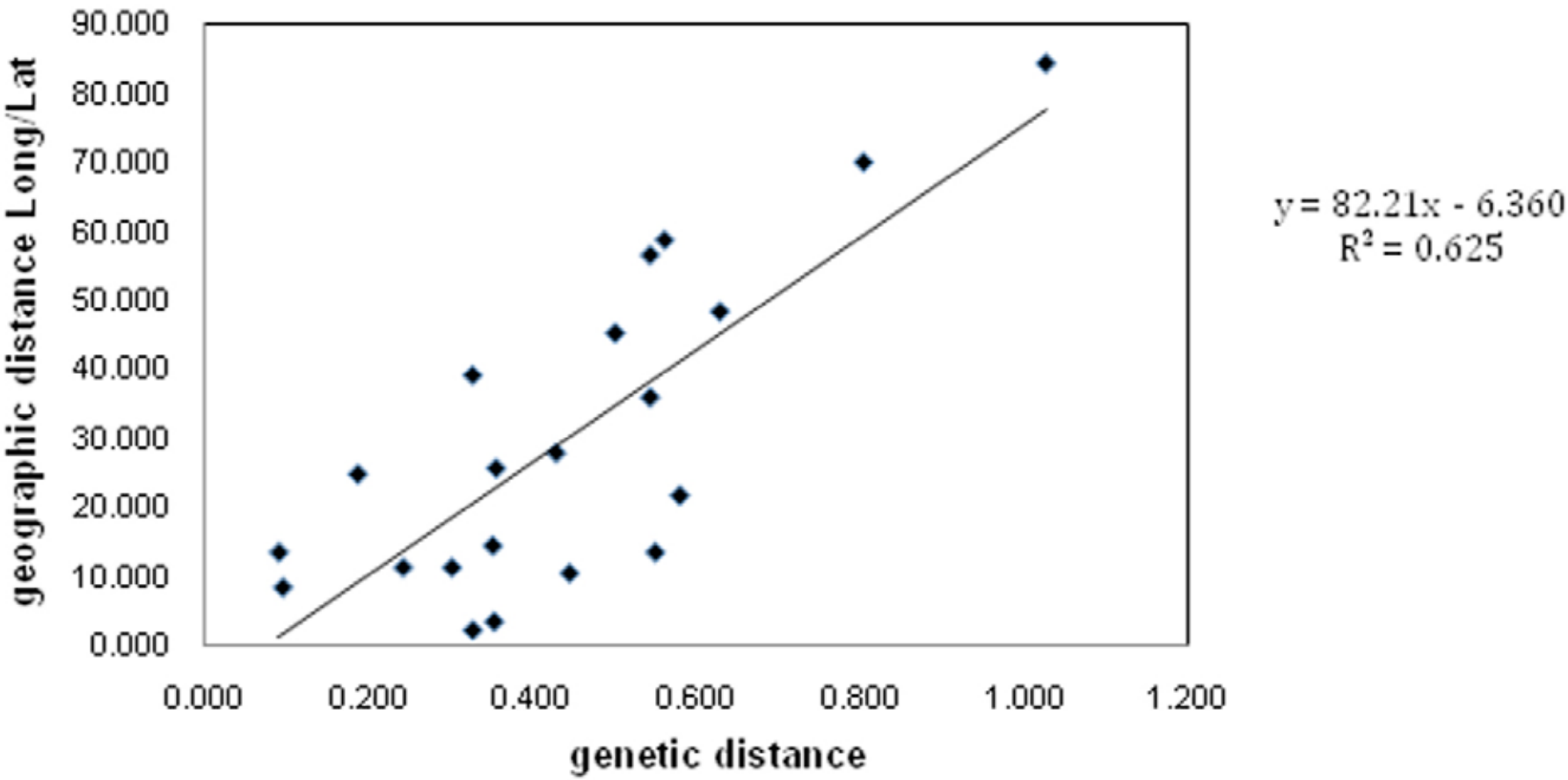
Continent - Island

Island

One-dimensional stepping stone

Multi-dimensional stepping stone

Models of Gene Flow



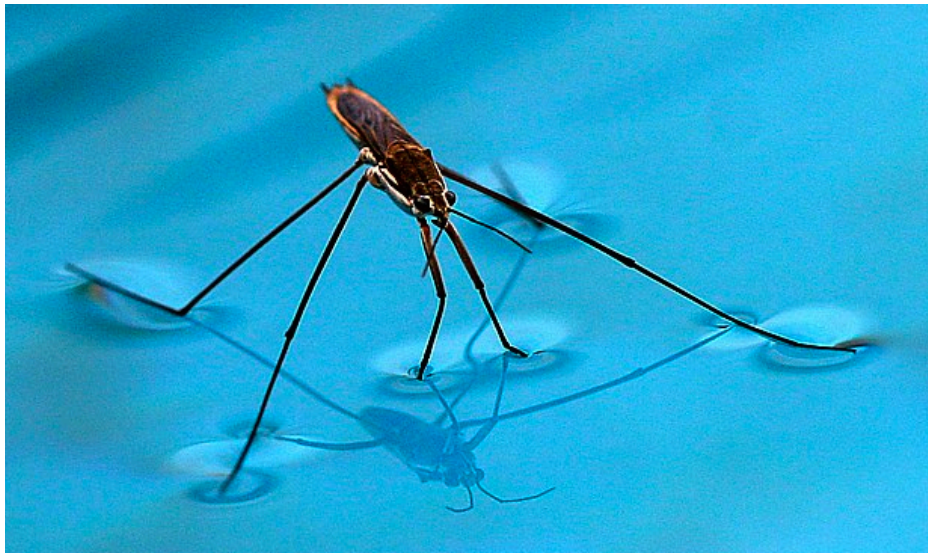
Isolation by distance.

Which model seems most realistic: isolation by distance or perfect panmixia (island model)?

Does migration always = gene flow?

What is the effect of gene flow on among population variation?

Studies of gene flow in species of high versus low vagility



http://www.eyefetch.com/image.aspx?ID=452439

http://www.encyclopediaofalabama.org/face/Multimedia.jsp?id=m-3167

The end